Chapter 8. San Diego Regional Survey Sediment Characteristics

INTRODUCTION

The City of San Diego has conducted summer regional surveys of sediment conditions on the mainland shelf off San Diego since 1994 in order to evaluate physical and chemical patterns and trends over a large geographic area. Such region-wide monitoring is designed to assess the quality and characteristics of sediments, as well as provide additional information that may help to differentiate reference areas from sites impacted by wastewater and stormwater discharge.

These regional surveys are based on arrays of stations that are randomly selected for each year using the USEPA probability-based EMAP design. The 1994, 1998, and 2003 surveys off San Diego were conducted as part of larger, multi-agency surveys of the entire Southern California Bight (SCB), including the 1994 Southern California Bight Pilot Project (SCBPP), and the Southern California Bight 1998 and 2003 Regional Monitoring Programs (Bight'98 and Bight'03, respectively). Results of sediment conditions from previous bightwide surveys are available in Noblet et al. (2002) and Schiff et al. (2006). The same randomized sampling design was used for surveys limited to the San Diego region in 1995–1997, 1999–2002, and 2005–2007. Additionally, during 2005, 2006 and 2007, the City revisited the same sites sampled 10 years earlier (i.e., 1995-1997, respectively) in order to facilitate comparisons of long-term changes in sediment conditions for the region.

This chapter presents analysis and interpretation of sediment particle size and chemistry data collected during the 2007 San Diego regional survey of randomized sites. Descriptions and comparisons of sediment conditions present in 2007 are included with analyses of levels and patterns of contamination relative to known and presumed sources.

MATERIALS AND METHODS

Field Sampling

The summer 2007 survey covered an area from off Del Mar in northern San Diego County southward to the USA/Mexico border (**Figure 8.1**). This survey revisited the sites selected for the 1997 regional survey, which was based on the USEPA probability-based EMAP sampling design (see City of San Diego 1998). The monitoring area included the section of the mainland shelf ranging from nearshore waters to shallow slope depths (13–216 m). Although 40 sites were initially selected for the 1997 and 2007 surveys, sampling at three sites in 1997

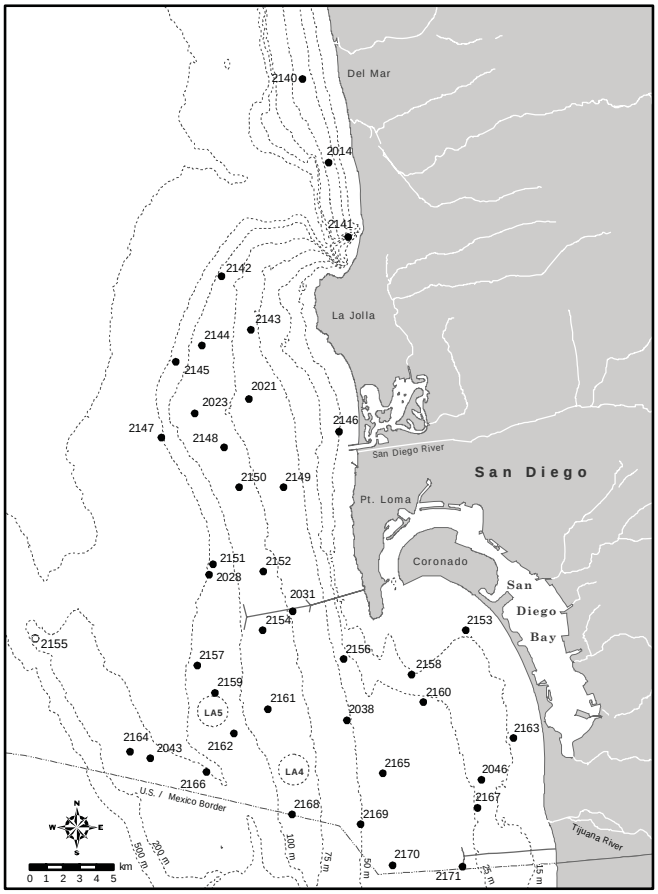

Figure 8.1
Randomly selected regional benthic stations sampled off San Diego, CA (July 2007). Open circles represent abandoned stations (see text).

Table 8.1

A subset of the Wentworth scale representative of the sediments encountered in the SBOO region. Particle size is presented in phi, microns, and millimeters along with the conversion algorithms. The sorting coefficients (standard deviation in phi units) are based on categories described by Folk (1968).

Wentworth scale				Sorting coefficient	
Phi size	Microns	Millimeters	Description	Standard deviation	Sorting
-2	4000	4	Pebble	Under 0.35 phi	very well sorted
-1	2000	2	Granule	0.35–0.50 phi	well sorted
0	1000	1	Very coarse sand	0.50–0.71 phi	moderately well sorted
1	500	0.5	Coarse sand	0.71–1.00 phi	moderately sorted
2	250	0.25	Medium sand	1.00–2.00 phi	poorly sorted
3	125	0.125	Fine sand	2.00–4.00 phi	very poorly sorted
4	62.5	0.0625	Very fine sand	Over 4.00 phi	extremely poorly sorted
5	31	0.0310	Coarse silt		
6	15.6	0.0156	Medium silt		
7	7.8	0.0078	Fine Silt		
8	3.9	0.0039	Very fine silt		
9	2.0	0.0020	Clay		
10	0.98	0.00098	Clay		
11	0.49	0.00049	Clay		

Conversions for diameter in phi to millimeters: $D(mm) = 2^{-phi}$

Conversions for diameter in millimeters to phi: $D(phi) = -3.3219\log_{10}D(mm)$

and one site in 2007 was unsuccessful due to the presence of rocky reefs. In addition, seven of the sites (stations 2014, 2021, 2023, 2028, 2031, 2038, 2046) were repeat stations that were sampled each year (i.e., 1995–1997, 2005–2007).

Each sample for sediment analysis was collected from one-half of a chain-rigged 0.1-m^2 double Van Veen grab; the other grab sample was used for macrofaunal community analysis (see Chapter 9). Sub-samples were taken from the top 2 cm of the sediment surface and handled according to EPA guidelines (USEPA 1987).

Laboratory Analyses

All sediment chemistry and grain size analyses were performed at the City of San Diego's Wastewater Chemistry Services Laboratory. Particle size analysis was performed using a Horiba LA–920 laser scattering particle analyzer, which measures particles ranging in size from 0.00049 to 2.0 mm (i.e., 11 to -1 phi). Coarser sediments (e.g., coarse sand, gravel, shell hash) were removed prior to analysis by screening the samples through a 2.0-mm mesh sieve. These data were expressed as "% Coarse" of the total sample sieved.

Output from the Horiba particle size analyzer was categorized as follows: sand was defined as particles ranging from >0.0625 to 2.0 mm in size, silt as particles from 0.0625 to 0.0039 mm, and clay as particles <0.0039 mm (see **Table 8.1**). These data were standardized and combined with any sieved coarse fraction (i.e., particles >2.0 mm) to obtain a distribution of coarse, sand, silt, and clay totaling 100%. The coarse fraction was included with the ≥2.0 mm fraction in the calculation of various particle size parameters, which were determined using a normal probability scale (see Folk 1968). These parameters were summarized and expressed as overall mean particle size (mm), phi size (mean, median, skewness, and kurtosis), and the proportion of coarse, sand, silt, and clay. The proportion of fine particles (% fines) was calculated as the sum of all silt and clay fractions.

Sediment samples were analyzed for the chemical constituents specified by the NPDES permits under

which sampling was performed. These parameters include total organic carbon (TOC), total nitrogen (TN), total sulfides, trace metals, chlorinated pesticides (e.g., DDT), polychlorinated biphenyl compounds (PCBs), and polycyclic aromatic hydrocarbons (PAHs) (see **Appendix C.1**). TOC and TN were measured as percent weight (%wt) of the sediment sample; sulfides and metals were measured in units of mg/kg and expressed as parts per million (ppm); pesticides and PCBs were measured in units of ng/kg and expressed as parts per trillion (ppt); PAHs were measured in units of µg/kg and expressed as parts per billion (ppb). The data reported herein were generally limited to values above the method detection limit (MDL). However, concentrations below MDLs were included as estimated values if the presence of the specific constituent could be verified by mass-spectrometry (i.e., spectral peaks confirmed). A detailed description of the analytical protocols may be obtained from the City of San Diego Wastewater Chemistry Services Laboratory (City of San Diego 2008).

Data Analyses

Values for total PAH, total DDT and total PCB were calculated for each sample as the sum of all constituents with reported values. Zeroes were substituted for all non-detects (i.e., null values) when calculating means. Summaries of parameters included detection rates (i.e., total number of reported values/total number of samples), the minimum and maximum value of each parameter during the year, and annual means for all stations combined (areal mean). Data are also summarized by depth strata used in the Bight'98 and Bight'03 regional surveys of the entire SCB including shallow shelf (5–30 m), mid-shelf (30–120 m), and deep shelf (120–200 m). Annual means from 2007 were compared to mean values from the 1997 Regional Survey.

Results

Particle Size Analysis

With few exceptions, the overall composition of sediments off San Diego in 2007 consisted of fine sands and silts (**Figure 8.2, Table 8.2**). Geographic distributions were similar to those observed in previous surveys: i.e., higher sand content in shallow nearshore areas, and decreasing to a mixture of mostly coarse silt and very fine sand at the mid-shelf region and at deeper offshore sites (see City of San Diego 1998, 2000–2003, 2006, 2007). Overall, these sediments reflect the diverse and patchy habitats common to the SCB. Eight of the 2007 sites were located in shallow shelf depths ≤30 m. The sediments at these shallow sites were composed of about 90% sands and 9% fines with an average particle size of approximately 0.15 mm (Table 8.2). Mid-shelf stations located at depths of 30–120 m represented most of the sites sampled off San Diego during the year (n=22). These sites generally had finer sediments composed of about 60% sands and 37% fines with a mean particle size of about 0.13 mm. The nine deepest sites that occurred at depths of 120–200 m contained sediments of about 52% sands and 47% fines with an average particle size of about 0.08 mm.

Almost all of the 2007 survey sites located south of Point Loma and at depths of 19–55 m had sediments composed of <25% fines (Figure 8.2). These results are very similar to those from the regular fixed-grid stations surrounding the SBOO (see Chapter 4). Sediments from deeper mid-shelf sites in this South Bay region tended to be coarser and have less fine materials than regional stations at similar depths located off of Point Loma and further to the north. This may be due at least in part to the multiple geological origins of red relict sands, shell hash, coarse sands, and other detrital sediments in the South Bay region (Emery 1960).

Sediment particle size composition along the San Diego shelf in 2007 was generally similar to that sampled at the same sites in 1997 (**Table 8.3**). Only seven of the stations sampled in 2007 had sediments differing by more than 0.05 mm in mean particle size from the 1997 samples **(Appendix F.2)**. For these seven stations, average particle size decreased at three sites (stations 2043, 2156 and 2146) between 1997 and 2007, and increased at four other sites (stations 2169, 2165, 2170 and 2023).

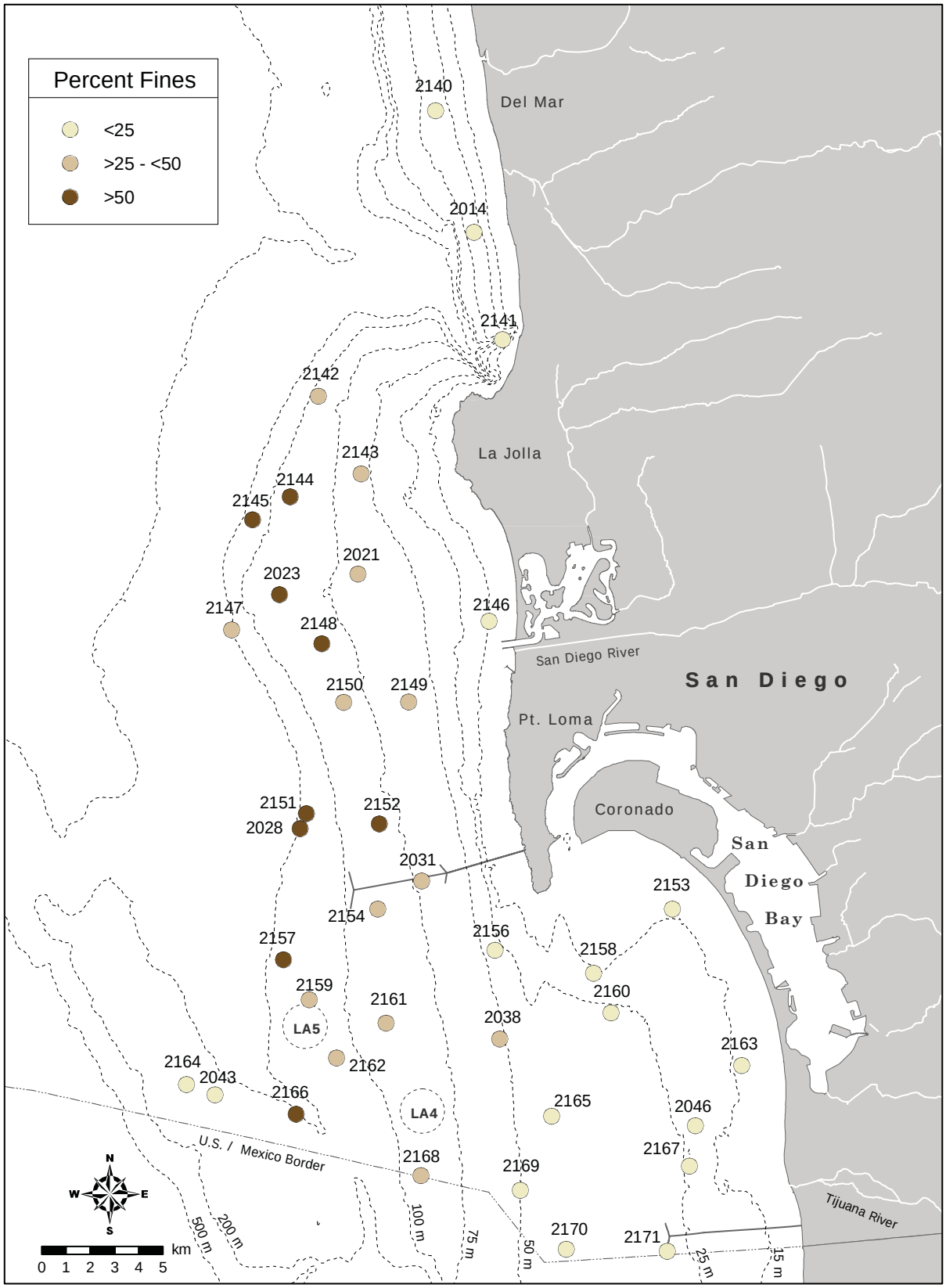

Figure 8.2
Particle size distribution for regional benthic stations sampled off San Diego, CA (July 2007).

Table 8.2

Summary of particle size parameters for the 2007 regional survey stations. Abbreviated observations are: Sh=shell hash; G=gravel; R=rock; Od=organic debris; Sg=surfgrass; Rrs=red relic sand; Cbs=coarse black sand; M=mud; Cs=coarse sand; Ct=chaetopterid tubes.

	Station	Depth (m)	Mean (mm)	Mean (phi)	SD (phi)	Coarse (%)	Sand (%)	Silt (%)	Clay (%)	Fines (%)	Observations
Shallow Shelf	2153	13	0.159	2.6	0.7	0.0	94.1	5.9	0.0	5.9	Sh, G, R
	2146	14	0.137	2.9	0.5	0.0	93.8	6.2	0.0	6.2	
	2163	15	0.116	3.1	1.0	3.3	82.8	13.4	0.5	13.9	Sh
	2158	16	0.286	1.8	0.9	3.5	96.2	0.3	0.0	0.3	Sh
	2046	22	0.122	3.0	0.5	0.0	91.6	8.3	0.1	8.4	
	2167	25	0.102	3.3	0.8	0.0	86.1	13.5	0.4	13.9	Od
	2160	26	0.109	3.2	1.0	0.0	83.3	15.8	0.8	16.6	Od
	2171	29	0.204	2.3	1.2	2.5	92.1	5.4	0.0	5.4	Sh
	Mean	20	0.154	2.8	0.8	1.2	90.0	8.6	0.2	8.8	
Mid-shelf	2141	36	0.096	3.4	1.5	0.0	75.4	23.0	1.6	24.6	Od, Sg
	2156	36	0.130	2.9	1.1	0.0	85.4	13.7	0.9	14.6	Od, Sh
	2014	38	0.088	3.5	1.2	0.0	75.3	23.3	1.4	24.7	Od, Sh
	2140	38	0.088	3.5	1.2	0.0	78.1	20.4	1.4	21.8	
	2170	42	0.528	0.9	0.7	8.8	90.2	0.9	0.0	0.9	Rrs, Sh
	2165	43	0.280	1.8	1.1	0.2	92.3	7.3	0.2	7.5	Cbs, Sh
	2169	49	0.615	0.7	0.7	12.7	86.7	0.5	0.0	0.5	Rrs, Sh
	2038	52	0.063	4.0	1.4	0.0	66.4	31.3	2.3	33.6	Sh, M, G
	2143	57	0.056	4.2	1.6	0.0	61.9	35.2	2.8	38.0	Od, Sh
	2149	63	0.049	4.3	1.5	0.0	52.3	44.9	2.8	47.7	Od, Sh
	2021	67	0.048	4.4	1.7	2.2	49.2	44.6	4.0	48.6	Sh, M, G
	2031	74	0.050	4.3	1.5	0.0	53.8	43.4	2.9	46.3	
	2150	82	0.048	4.4	1.6	0.0	50.1	46.7	3.2	49.9	
	2152	82	0.044	4.5	1.5	0.0	45.9	51.1	3.0	54.1	
	2148	83	0.038	4.7	1.5	0.0	37.1	58.7	4.2	62.9	
	2154	88	0.053	4.2	1.5	0.0	57.3	40.0	2.7	42.7	
	2168	88	0.059	4.1	1.6	0.0	65.4	32.0	2.6	34.6	
	2161	89	0.055	4.2	1.9	3.4	52.5	40.3	3.8	44.1	Cs, Sh, G, R
	2023	90	0.190	2.4	2.2	23.8	21.6	54.6	0.0	54.6	M, G
	2144	93	0.043	4.5	1.6	0.0	46.4	49.9	3.7	53.6	
	2142	96	0.047	4.4	1.5	0.0	51.7	44.8	3.5	48.3	
	2145	116	0.109	3.2	1.4	5.5	28.7	65.8	0.0	65.8	Sh, G, R
	Mean	68	0.126	3.6	1.4	2.6	60.2	35.1	2.1	37.2	
Deep shelf	2162	130	0.053	4.2	2.0	2.1	51.9	41.7	4.3	46.0	Cs, Sh, G, R
	2164	136	0.281	1.8	1.1	4.3	83.5	12.2	0.0	12.2	Sh, M, G
	2159	160	0.048	4.4	1.9	0.0	50.7	44.4	4.9	49.3	Cs, Sh, G, R
	2043	171	0.157	2.7	1.6	0.0	83.4	15.4	1.2	16.6	Od, Sh
	2151	177	0.038	4.7	1.6	0.0	40.3	55.3	4.3	59.6	Od, Ct
	2157	186	0.030	5.0	1.6	0.0	29.4	65.4	5.3	70.7	Od, Ct
	2028	190	0.037	4.8	1.6	0.0	38.2	57.5	4.3	61.8	Od, Ct
	2147	193	0.048	4.4	1.9	0.0	54.5	40.2	5.3	45.5	Sh, G
	2166	216	0.036	4.8	1.9	0.0	40.1	54.2	5.7	59.9	Od, M, G, Sh
	Mean	173	0.081	4.1	1.7	0.7	52.4	42.9	3.9	46.8	

Table 8.3

Summary of sediment contaminants from the 1997 and 2007 regional surveys. Parameters are summarized as mean values per major depth strata for 2007; minimum (Min), maximum (Max) and mean values for the 2007 and 1997 survey areas.

		2007 by Strata			2007 Survey Area			1997 Survey Area		
	Units	Shallow	Mid	Deep	Min	Max	Mean	Min	Max	Mean
Depth	m	20	68	173	13	216	83	13	194	77
Fines	%	9	37	47	0	71	34	nd	78	31
Sulfides	ppm	7.1	9.4	12.9	nd	97.3	9.8	nd	272.0	16.8
TN	%wt	0.02	0.06	0.10	nd	0.15	0.06	nd	0.15	0.05
TOC	%wt	0.18	0.83	2.52	0.05	8.17	1.09	nd	1.53	0.50
HCB	ppt	14	153	74	nd	1100	106	nd	nd	nd
tDDT	ppt	7	153	30	nd	580	95	nd	1600	43
tPCB	ppt	nd	299	371	nd	6360	254	na	na	na
tPAH	ppb	57.6	35.0	52.3	nd	176.7	43.6	nd	nd	nd
Metals										
Al	ppm	4498	10877	15089	991	22400	10541	1150	23500	10793
Sb	ppm	1.73	0.60	0.56	nd	2.45	0.82	nd	13.80	1.76
As	ppm	1.84	3.51	2.83	0.96	7.35	3.01	1.1	6.95	3.42
Ba	ppm	20.9	48.1	58.0	2.4	142.0	44.8	na	na	na
Cd	ppm	0.23	0.06	0.15	nd	0.32	0.12	nd	0.75	0.06
Cr	ppm	7.9	18.1	26.7	4.2	38.2	18.0	7.4	36.4	18.2
Cu	ppm	1.3	5.0	12.3	nd	25.4	5.9	nd	40.6	8.9
Fe	ppm	5729	14375	18466	3210	37500	13546	4530	22500	11577
Pb	ppm	1.41	2.92	7.34	0.15	33.90	3.63	nd	8.00	0.83
Mn	ppm	63.2	112.9	121.9	13.5	183.0	105.1	13.2	149.0	89.2
Hg	ppm	0.003	0.025	0.062	nd	0.169	0.029	nd	0.113	0.011
Ni	ppm	2.5	6.6	10.9	0.9	16.0	6.8	nd	21.4	7.1
Se	ppm	nd	0.09	0.28	nd	0.67	0.12	nd	0.84	0.24
Ag	ppm	1.31	3.28	2.30	nd	8.35	2.65	nd	nd	nd
Tl	ppm	0.13	0.47	0.18	nd	1.01	0.34	nd	nd	nd
Sn	ppm	0.86	1.58	1.76	nd	2.69	1.44	nd	nd	nd
Zn	ppm	13.5	31.9	45.4	6.5	61.9	31.3	5.3	71.8	30.4

Organic Indicators

Concentrations of total organic carbon (TOC) and nitrogen (TN) increased with depth, corresponding to the percent fines in each depth strata (see Table 8.3). TOC averaged 0.18% at the shallow water stations, 0.8% at the mid-shelf stations, and 2.52% at the deep shelf stations. TN averaged 0.02% at the shallow sites, 0.06% at the mid-shelf sites, and 0.1% at the deep shelf sites. Sediments at two stations located along the Coronado Bank had the highest concentrations of TOC (8.17% at station 2164) and TN (0.15% at station 2166; **Table 8.4**); sediments in this area have consistently had high concentrations of organics despite the presence of overall coarse sediments relative to other deep shelf stations (see City of San Diego 2007). Most other regional sites with relatively high TOC concentrations (>1.5%) occurred along the 200-m depth contour from Point Loma northward (i.e., stations 2157, 2028, 2151, 2147). Sediments at these stations also had some of the highest TN concentrations (>0.10%). As with particle size, TOC and TN concentrations at South Bay regional sites were similar to results from the fixed-grid stations surrounding the SBOO (see Chapter 4). The region-wide mean concentration of TN (0.06%) in 2007 was slightly higher than the 1997 average (0.05%; see Table 8.3). In contrast, the 2007 region-wide mean for

TOC (1.09%) was more than 50% above the 1997 average (0.5%; Table 8.3). The higher average TOC value for 2007 reflects the much higher TOC concentrations that occurred at the deep shelf stations (i.e., mean=2.52%; maximum=8.17%).

Concentrations of sulfides also increased between depth strata. For example, sulfide concentrations averaged about 7.1 ppm at the shallow water stations, 9.4 ppm at the mid-shelf stations, and 12.9 ppm at the deep shelf sites (Table 8.3). The highest sulfide concentration (97.3 ppm) was found in sediments from station 2141 located at a depth of 36 m west of La Jolla Shores (see Table 8.4 and Figure 8.1). Other relatively high sulfide values (i.e., ≥19.4 ppm) occurred in sediments off of Mission Beach (station 2146), near the Point Loma outfall (station 2154), near LA-5 dredge disposal site (stations 2162 and 2159), and at a depth of 186 m located between the Point Loma outfall and LA-5 (station 2157). In contrast, sulfides were very low or not-detected in sediments from regional and fixed-grid stations surrounding the SBOO (see Table 8.4 and Chapter 4). Region-wide sulfide concentrations from this study were well within the range of values reported for 1997 (Table 8.3).

Trace Metals

Fifteen different metals (i.e., aluminum, antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver, tin, and zinc) were detected in sediments at more than 75% of the regional stations sampled in 2007 (Table 8.4). Two additional metals, selenium and thallium, were detected at only 26% and 59% of the stations, respectively, while beryllium was not detected at any site. Concentrations of several metals, including aluminum, barium, chromium, copper, iron, lead, manganese, mercury, nickel, tin and zinc increased with depth and percent fines (Table 8.3), a pattern similar to that observed for various indicators of organic loading. For these metals, the highest concentrations tended to occur at the deeper sites that had the largest proportion of fine particles (see above). Concentrations of some metals also appeared to be associated with the LA-5 dredge spoils disposal site. For example, stations 2159 and 2162 located nearest LA-5, and station 2161 located just inshore of the disposal site, had sediments with some of the highest concentrations of several metals (i.e., aluminum, arsenic, chromium, copper, lead, mercury, thallium, and zinc); however, sediments at these sites had only moderate proportions of fine particles (i.e., 44-49%, see Table 8.2).

No associations were apparent between high values of metals and distance from the ocean outfalls in either the Point Loma or South Bay regions. Even though the site located closest to the SBOO (station 2171) had sediments with relatively high concentrations of antimony and cadmium, values of these two metals were high throughout the entire SBOO area (Table 8.4). In fact, mean concentrations of these and all other metals from the regular SBOO fixed grid program (see Chapter 4) were similar to, or lower than, regional survey averages (Table 8.3). Additionally, most metals occurred in sediments during 2007 at concentrations similar to, or lower than, values detected in 1997 (Table 8.3). All of the exceptions (i.e., cadmium, lead, mercury, silver, thallium and tin) had substantially higher detection limits in 1997. For example, lead had an MDL of 5 ppm in 1997 versus 0.142 ppm in 2007. Since zeros are substituted for non-detects when calculating means, lower detection limits result in higher detection rates and therefore higher mean concentrations.

Pesticides, PCBs and PAHs

Pesticides had low detection rates (≤23%) in regional sediments during 2007 (Table 8.4). Hexachlorobenzene (HCB) was detected at up to four stations per depth strata and at maximum concentrations of 1100 ppt. This pesticide was detected in sediments from two sites located to the north or offshore of La Jolla (stations 2141 and 2142), two sites located southwest of the mouth of the San Diego River (stations 2149

Table 8.4

Concentrations of contaminants in sediments from 2007 regional stations. TN=total nitrogen; TOC=total organic carbon; HCB=hexachlorobenzene; tDDT=total DDT; tPCB= total PCB; tPAH=total PAH; No.=number of PAH detected in each sample; CDF=cumulative distribution function; nd=not detected. See Appendix C.1 for names and periodic table symbols.

Station		Depth (m)	Sulfides (ppm)	TN (%)	TOC (%)	HCB (ppt)	tDDT (ppt)	tPCB (ppt)	tPAH (ppb)	tPAH No.
Shallow shelf	2153	13	8.33	0.02	0.19	nd	nd	nd	57.6	3
	2146	14	19.40	0.02	0.19	nd	nd	nd	18.3	2
	2163	15	10.60	0.02	0.15	nd	nd	nd	61.8	4
	2158	16	nd	nd	0.09	nd	nd	nd	24.1	2
	2046	22	1.78	0.01	0.12	110	59	nd	38.3	3
	2167	25	3.50	0.02	0.24	nd	nd	nd	176.7	9
	2160	26	13.50	0.04	0.36	nd	nd	nd	33.9	2
	2171	29	nd	0.01	0.11	nd	nd	nd	50.5	3
Mid-shelf	2141	36	97.30	0.05	0.58	260	450	nd	32.8	2
	2156	36	5.24	0.03	0.71	nd	nd	nd	29.4	2
	2014	38	10.30	0.04	0.38	nd	nd	nd	41.4	3
	2140	38	6.69	0.03	0.30	nd	nd	nd	59.1	4
	2170	42	nd	0.01	0.08	nd	nd	nd	59.4	4
	2165	43	nd	0.01	0.08	nd	410	nd	20.0	1
	2169	49	nd	nd	0.05	nd	nd	nd	17.0	1
	2038	52	0.90	0.05	0.54	190	nd	6360	38.8	3
	2143	57	3.29	0.06	0.59	nd	nd	nd	22.9	2
	2149	63	1.51	0.07	0.72	1000	nd	nd	24.7	2
	2021	67	0.68	0.07	1.39	nd	nd	nd	25.6	2
	2031	74	6.32	0.07	1.84	nd	540	nd	54.4	3
	2150	82	9.18	0.07	0.78	1100	nd	nd	28.2	2
	2152	82	5.48	0.08	0.88	nd	580	220	27.4	2
	2148	83	2.40	0.09	0.99	nd	nd	nd	61.5	4
	2154	87	27.60	0.07	0.75	nd	490	nd	45.3	2
	2168	88	7.37	0.06	0.77	nd	520	nd	25.9	2
	2161	89	6.36	0.06	0.75	nd	380	nd	nd	0
	2023	90	0.30	0.07	1.28	nd	nd	nd	24.3	2
	2144	93	5.22	0.07	0.88	nd	nd	nd	22.5	2
	2142	96	4.71	0.07	0.77	810	nd	nd	76.1	5
	2145	116	6.04	0.06	3.10	nd	nd	nd	32.6	3
Deep shelf	2162	130	29.40	0.06	0.67	nd	nd	1020	27.8	1
	2164	136	0.21	0.06	8.17	nd	nd	nd	22.4	1
	2159	160	35.10	0.07	0.88	nd	270	1870	126.6	4
	2043	171	5.64	0.04	1.48	670	nd	nd	32.4	3
	2151	177	6.79	0.12	1.59	nd	nd	nd	28.5	2
	2157	186	25.00	0.14	2.04	nd	nd	450	47.1	2
	2028	190	11.30	0.13	1.70	nd	nd	nd	46.3	2
	2147	193	1.93	0.10	3.06	nd	nd	nd	109.6	6
	2166	216	0.97	0.15	3.08	nd	nd	nd	29.8	2
Detection rate (%)			87	95	100	18	23	13	97	

Table 8.4 *continued*.

Metals (ppm)																
Al	**Sb**	**As**	**Ba**	**Cd**	**Cr**	**Cu**	**Fe**	**Pb**	**Mn**	**Hg**	**Ni**	**Se**	**Ag**	**Tl**	**Sn**	**Zn**
9400	0.20	4.8	na	0.29	34.0	12.0	16800	na	na	0.40	na	0.29	0.2	na	na	56.0
4110	1.75	1.9	15.7	0.26	6.5	1.0	4820	0.9	53.9	nd	2.2	nd	0.7	nd	0.88	12.6
4390	0.22	1.0	22.8	nd	9.6	0.2	8100	1.3	116.0	nd	1.6	nd	4.4	1.01	1.20	15.2
4080	1.78	1.8	18.9	0.30	7.0	1.3	4150	0.5	50.4	nd	2.3	nd	0.8	nd	0.67	11.1
2050	1.74	1.6	9.6	0.20	4.2	0.6	3210	1.5	33.5	0.001	1.3	nd	0.3	nd	0.68	6.9
4580	1.47	1.5	22.0	0.18	7.0	0.9	4560	0.2	52.6	nd	2.2	nd	1.0	nd	0.54	10.3
6600	2.45	2.0	27.8	0.32	9.9	1.7	6870	0.7	67.6	0.001	4.0	nd	1.1	nd	1.26	16.5
7400	2.13	2.7	36.6	0.31	11.6	3.9	9410	5.5	94.8	0.01	4.5	nd	1.8	nd	0.55	24.7
2770	2.28	2.3	13.5	0.28	7.4	0.5	4710	0.8	36.9	nd	2.0	nd	0.3	nd	1.10	10.9
12400	2.08	2.4	73.7	0.07	18.8	6.1	16500	2.1	154.0	0.01	6.5	nd	5.5	0.53	1.42	44.1
6350	0.23	2.2	33.6	0.04	10.1	3.3	7700	2.2	97.4	0.02	2.9	nd	2.0	0.53	1.11	24.3
12700	0.29	2.8	67.1	0.06	19.4	5.3	15100	2.1	149.0	0.005	6.4	nd	5.3	0.49	1.57	40.6
9830	0.31	2.0	47.9	0.07	15.3	3.8	11200	1.7	120.0	nd	4.8	nd	4.4	0.63	1.39	28.0
991	2.36	6.3	2.4	0.31	10.0	nd	6940	1.9	13.5	nd	1.3	nd	nd	nd	1.04	6.5
3540	0.16	2.7	9.3	0.01	7.9	2.0	5810	1.2	40.8	0.003	1.9	nd	1.3	0.29	0.92	12.0
1980	0.21	7.0	3.3	nd	8.7	nd	7670	2.3	25.0	nd	0.9	nd	nd	nd	0.90	10.5
11200	0.26	3.5	40.0	0.06	16.0	4.5	11400	3.2	121.0	0.03	6.2	nd	8.3	0.81	1.47	29.1
11400	0.23	2.7	51.7	0.07	18.8	4.7	14900	3.7	120.0	0.02	6.4	nd	2.8	0.70	1.87	33.8
13700	0.73	3.8	59.1	0.10	22.0	6.4	16800	4.1	147.0	0.04	8.8	nd	4.6	0.72	2.28	38.0
13700	0.78	4.7	52.6	0.09	22.3	7.1	17300	4.0	145.0	0.03	8.6	0.41	4.0	0.68	2.20	39.8
8630	nd	3.4	36.0	nd	12.6	4.8	9240	2.9	79.8	0.05	5.4	nd	2.3	0.24	0.85	23.1
13400	0.87	3.3	50.5	0.05	22.1	6.6	16700	3.8	143.0	0.04	9.5	0.56	6.1	0.84	2.69	36.0
17300	0.53	2.6	63.2	0.09	24.2	8.9	18500	5.0	148.0	0.05	10.4	nd	4.7	0.69	2.05	51.0
16600	0.84	2.7	64.9	0.04	26.7	9.2	20300	4.3	162.0	0.05	11.6	0.45	5.4	0.71	2.22	44.1
12100	0.40	2.9	46.1	0.07	18.9	7.3	14400	3.8	107.0	0.03	8.2	0.28	2.0	0.40	1.77	33.2
9030	0.23	3.0	28.4	0.03	14.4	4.7	10300	2.2	92.4	0.02	7.0	nd	1.7	0.45	1.18	27.4
11300	0.15	4.1	47.3	nd	11.8	6.0	11200	0.2	86.0	0.04	4.9	nd	2.0	0.81	0.76	23.6
16900	1.39	7.3	142.0	0.02	38.2	3.1	37500	5.1	183.0	0.04	11.2	0.28	1.9	nd	2.23	55.0
13500	0.53	2.6	54.6	0.03	21.4	6.3	16500	3.2	123.0	0.03	8.6	nd	2.6	0.40	1.60	36.9
13400	0.41	2.5	49.2	0.10	21.1	5.6	16300	2.9	131.0	0.03	8.1	nd	3.8	nd	1.81	35.8
9350	0.27	2.7	34.7	0.09	17.5	4.4	14000	2.4	96.6	0.02	6.1	nd	1.2	0.52	1.46	29.7
16900	0.50	2.7	72.7	0.03	23.3	13.3	18100	33.9	145.0	0.06	8.3	nd	2.0	0.41	1.81	46.1
5810	0.67	2.9	20.8	0.24	27.1	2.6	18600	2.7	40.8	0.02	6.4	nd	nd	nd	0.71	40.0
19900	0.59	5.3	79.2	0.03	26.3	25.1	21200	5.1	171.0	0.11	9.7	nd	2.5	0.82	1.81	52.8
3890	nd	2.5	17.1	0.04	13.3	1.9	6990	1.7	31.3	0.01	3.7	nd	0.3	nd	0.90	15.5
16900	0.38	2.2	58.0	0.18	27.2	11.5	18700	4.4	137.0	0.05	13.7	0.40	3.2	0.17	2.21	47.7
22400	0.93	3.1	81.8	0.19	34.5	25.4	23700	8.0	164.0	0.17	15.7	0.67	4.2	0.23	2.65	61.9
18800	0.51	2.2	62.2	0.18	28.5	11.8	19800	3.9	148.0	0.05	14.4	0.44	4.2	nd	2.05	49.0
12100	0.63	1.9	42.0	0.28	26.0	7.1	18500	3.0	106.0	0.03	9.9	0.52	1.9	nd	1.96	41.9
100	95	100	100	90	100	95	100	100	95	79	100	26	92	59	100	100

and 2150), one southern site on the Coronado Bank (station 2043), and two stations located in the regular (fixed grid) SBOO monitoring area (stations 2038 and 2046). The pesticide DDT was also detected in sediments from each depth strata. These included three stations located relatively close to the Point Loma outfall (stations 2031, 2152 and 2154), two stations located adjacent to or just inshore of the LA-5 disposal site (stations 2159 and 2161), two stations within the regular SBOO monitoring area (stations 2046 and 2165), one station just south of the old LA-4 disposal site (station 2168), and one station located just north of Scripps Canyon (station 2141). The mean concentration of total DDT was 95 ppt, which is slightly higher than the mean concentration of 43 ppt from 1997 (see Table .3). This difference is likely due to the inclusion of estimated values in the analyses performed in 2007 (see Methods), a practice that was not begun until 2003. Total DDT concentrations at the regular fixed grid SBOO stations were well within values found during the 2007 regional survey.

PCBs were detected in sediments from a total of five sites located in the mid and deep shelf strata. Sediments at station 2038 located south of Point Loma between the mouth of San Diego Bay and the LA-4 disposal site had the highest total PCB concentration of 6360 ppt. The four other sites with detectable PCBs had concentrations <2000 ppt. These sites included stations 2159 and 2162 located near LA-5, station 2157 located southwest of the Point Loma outfall discharge area, and station 2152 located north of the Point Loma outfall. Total PCB from the SBOO grid stations (see Chapter 4) was much lower than from these regional sites. None of the PCB data from 2007 can be compared to historical data from 1997 since PCBs were analyzed as Arochlors and not congeners prior to 1999.

In contrast to pesticides and PCBs, PAHs were widely distributed in regional sediments but at low concentrations (≤177 ppb). Station 2167, located on the shallow shelf north of the SBOO, had sediments with the highest total PAH concentration. Other sites with PAH concentrations >100 ppb included station 2159 located adjacent to the LA-5 disposal site, and station 2147 located offshore of Mission Beach at a depth of 193 m. No PAHs were detected in 1997, which was likely due to higher detection limits at the time (Table 8.3).

Summary and Conclusions

Grain-size distribution at the regional benthic stations sampled in 2007 was similar to that seen in previous years. For example, substantial changes in average particle size between 1997 and 2007 were observed for only seven sites. As in the past, there was a trend towards higher sand content in nearshore areas compared to finer sands and silt at deeper offshore sites. Sediments from depths ≤30 m were composed of about 90% sands and 9% fines, whereas sediments at depths of 30–120 m were about 60% sands and 37% fines. Deeper sites occurring at depths of 120–200 m had sediments composed of about 52% sands and 47% fines. Exceptions to the general pattern occurred in some mid-shelf sediments further offshore of the SBOO, as well as along the Coronado Bank, a southern rocky ridge located southwest of Point Loma at a depth of 150–170 m. Sediment composition at stations from these areas tended to be coarser than regional mid-shelf stations located off of Point Loma and further to the north. Overall, the sediments throughout the San Diego region reflect the diverse and patchy types of habitats that are common to the Southern California Bight.

Patterns in sediment chemistries at the regional sites in 2007 generally followed the expected relationship of increasing concentrations with decreasing particle size. Concentrations of organic indicators, metals, and other contaminants were higher along the mid-shelf and deep water strata where the percentage of fines was typically greatest. The regional sediment survey data did not show any pattern of contamination relative to wastewater discharges off San Diego.

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